REMARKS

Applicants have thoroughly considered the Examiner's remarks and respectfully request reconsideration of the application as amended. Claims 1 and 9 have been amended by this Amendment B; claims 1-10 are pending. Attached hereto is a marked-up version of the changes made to the claims by the current amendment. The attached pages are captioned "Version With Markings To Show Changes Made."

Claims 1 and 9 stand rejected under 35 U.S.C. 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicants regard as the invention. Specifically, the Examiner considers the claims to be rendered indefinite by the term "predetermined." Claims 1 and 9 have been amended in accordance with Examiner's remarks to more clearly set forth the invention. Claim 1 now recites "pulling the ingot from the melt at a target pull rate, said target pull rate substantially following a velocity profile, said velocity profile stored in memory and defining the target pull rate as a function of the length of the ingot during pulling." Claim 9 has been amended to remove the term "predetermined." Accordingly, claims 1 and 9 are believed to comply with § 112.

Claims 1-6 and 9-10 stand rejected under 35 U.S.C. 103(a) as being unpatentable over Cope, U.S. Patent No. 3,761,692. The Examiner admits that the Cope reference fails to show every feature of the claimed invention and asserts that the Cope system differs from the present invention only in that PID control is also performed by Cope on the pull rate. To remedy this deficiency, the Examiner notes that "the pull rate adjustments reads on the application's substantially following a set velocity profile because the average pull rate profile of Cope is determined by the upper and lower imposed limits thereon."

In this instance, the Examiner has improperly used hindsight reasoning in his analysis. In particular, the Examiner uses improper hindsight analysis where he states "[t]he pull rate must be set to something in the Cope reference." (See final Office action at page 6). According to the Federal Circuit, "the proper time to apply the obviousness test is that moment just before the invention was made." Stratoflex Inc. v. Aeroquip Corp., 713 F.2d 1530, 1538 (Fed. Cir. 1983).

Thus, although it is true that the pull rate must be set to some pull rate, the proper inquiry is whether in view of the Cope reference it would have been obvious at the moment prior to applicants' invention to use the pull rate as claimed by applicants. Applicants respectfully submit that pulling at a locked target rate in accordance with a velocity profile that is stored in memory and is a function of crystal length is distinguishable from merely adjusting the pull rate within an upper and lower limit in response to diameter feedback during processing. The former simplifies control by reducing the number of processing parameters that are affected by current processing conditions and the latter complicates control by introducing a parameter that is both affected by current processing conditions and affects current processing conditions.

Throughout the disclosure, the Cope reference clearly teaches away from the present invention. For example, Cope discloses: "[a] controller 65 to maintain a crystal pull rate specified by [the] diameter control algorithm." (Cope, col. 5 lines 5-10); "the output of the diameter control algorithm is input to the averaging filter 84 in order to provide the average pull rate for the crystal rod as it is pulled." (Cope, col. 5 lines 31-32); and "a diameter control algorithm. . . receives inputs from sensing devices and calculate[s] set point signals for the respective controllers." (Cope col 2 line 60-62).

In contrast, the present invention relates to an improved method for controlling silicon crystal diameter in a ***locked*** seed growth process as set forth in claim 1 ("said target pull rate substantially following a velocity profile . . . stored in memory"). It is unnecessary to adjust the pull rate in response to changing process conditions (i.e., diameter) because the velocity profile stored in a memory defines a target pull rate which is predetermined ***as a function of crystal length during pulling***. (See application, page 14.) Applicants have defined relationships between diameter variations and melt temperature and between melt temperature and heater power to achieve diameter control without the need to vary or correct pull rate in response to diameter variations. (See application, page 21).

To this end, independent claim 1 now recites a method for controlling silicon crystal growth in which an ingot is pulled from the melt at a target rate "substantially following a velocity profile, said velocity profile stored in memory and defining the target pull rate as a

function of the length of the ingot during pulling" in combination with "defining a temperature model representative of variations in the temperature of the melt in response to variations in power supplied to a heater for heating the melt." PID control is then performed on a generated signal that is representative of an error between the target diameter and the measured diameter to determine a temperature set point. Further, claim 1 recites "determining a power set point for the power supplied to the heater from the temperature model as a function of the temperature set point generated by the PID control."

Nothing in the Cope reference teaches or suggests each and every feature of the claimed invention, particularly, pulling a crystal at a locked pull rate in accordance with a pre-defined velocity profile as a function of crystal length in combination with adjusting heater power to affect diameter changes. As discussed above, the prior art teaches away from such control because the delay in effecting melt temperature changes is thought to be unacceptable for diameter control. Advantageously, the present invention, as recited in claim 1, employs a temperature model not disclosed by the prior art. This enables ***accurate diameter control*** using only heater power and eliminating ***the pull rate variability required by Cope*** to control diameter.

For these reasons, applicants submit that claim 1 is allowable over the Cope reference. Claims 2-10 depend from claim 1 and are believed to be allowable for at least the same reasons as claim 1.

Moreover, applicants submit that the prior art references, whether considered separately or together, do not teach or suggest the method of claims 2-10 in which corrective adjustments to heater power, and not pull rate, are determined as a function of diameter variations. As described above, the Cope patent teaches away from applicants' claimed invention and does not suggest controlling temperature according to a temperature model to control crystal diameter. One of ordinary skill in the art would not have found it obvious to modify the teachings of the Cope patent, alone or in view of Araki, to meet the limitations of applicants' claims 2-10.

In view of the foregoing, applicants submit that claims 1-10 are now in condition for allowance and respectfully request favorable reconsideration of this application.

The Commissioner is hereby authorized to charge any fees that may be required during the entire pendency of this application to Deposit Account No. 19-1345.

Respectfully submitted,

Robert M. Bain, Reg. No. 36,736
SENNIGER, POWERS, LEAVITT & ROEDEL
One Metropolitan Square, 16th Floor
St. Louis, Missouri 63102
(314) 231-5400

Express Mail Receipt No. EV 027255401 US

VERSION WITH MARKINGS SHOWING CHANGES MADE

IN THE CLAIMS

Claims 1 and 9 have been amended as follows:

1 (twice amended). A method for use in combination with a crystal growing apparatus for growing a monocrystalline ingot according to the Czochralski process, said crystal growing apparatus having a heated crucible containing a semiconductor melt from which the ingot is grown, said ingot being grown on a seed crystal pulled from the melt, said method comprising the steps of:

defining a temperature model representative of variations in the temperature of the melt in response to variations in power supplied to a heater for heating the melt;

pulling the ingot from the melt at a target pull rate, said target pull rate substantially following a [predetermined] velocity profile, said velocity profile stored in memory and defining the target pull rate as a function of the length of the ingot during pulling;

generating a signal representative of an error between a target diameter of the ingot and a measured diameter of the ingot;

performing proportional-integral-derivative (PID) control on the error signal and generating a temperature set point as a function thereof, said temperature set point representing a target temperature of the melt;

determining a power set point for the power supplied to the heater from the temperature model as a function of the temperature set point generated by the PID control; and

adjusting the power supplied to the heater according to the power set point thereby changing the temperature of the melt to control the diameter of the ingot.

9 (amended). The method of claim 1 further comprising the step of varying the rate at which the ingot is pulled from the melt to control diameter of the ingot, said step of varying the pull rate occurring during growth of a first portion of the ingot and said step of pulling the ingot at the target pull rate substantially following the [predetermined] velocity profile occurring during growth of a second portion of the ingot.